*PAC-3 INSENSITIVE MUNITIONS/ FINAL HAZARD CLASSIFICATION (IM/FHC) TEST PROGRAM AND MULTIMEDIA DATABASE

Patricia S. Vittitow
U.S. Army Space and Missile Defense Command
PO Box 1500
ATTN: SMDC-TC-WS
Hunstville, AL 35807-3801

Abstract

The U.S. Army Space and Missile Defense Command (USASMDC) Integrated IM/FHC Test Program for the PATRIOT Advanced Capability – 3 (PAC-3) Program is progressing rapidly. The sub-scale tests have been completed, the detailed test plan has been approved by the Department of Defense (DOD) and full-scale testing has been completed at Eglin Air Force Base, Florida. The unique configurations of some of the full-scale tests proved challenging in satisfying both insensitive munitions (IM) and hazard classification data collection. In some instances the method of test is diametrically opposed for both test protocols. Therefore, instrumentation and method of restraint (in the rocket motor tests) required careful planning and consideration. This paper will discuss some of the aspects of the instrumentation used in the IM/FHC full-scale tests and the preliminary test results. In addition to the test methods, a short fall was recognized on how to best display the data collected. This led to the development of a new multimedia database that has been developed jointly between USASMDC and the Army Aviation and Missile Command (AMCOM). This database has several unique features. It is built around the IM/FHC detailed test plan, which serves as the blueprint for conducting the sub-scale and full-scale tests and in collecting, storing, and displaying the test results. This PC level computer program includes a conventional alpha-numeric (text) database with the ability to observe both static photographs and edited video clips, all within the PC and viewed on the computer screen without the need for ancillary video player equipment. The large storage capacity and advanced video technology now allow for significant video storage within the database in the form of compact disc (CD) record. This paper discusses the construction of the database and will show sample results from PAC-3 test data. A live demonstration of the operation of the system from a laptop computer will be provided at the conference.

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Introduction

In the early 1990's, the author recognized the need for and the savings that would result from the integration of explosive hazard classification testing performed according to U.S. Army Technical Bulletin (TB) 700-2 and IM testing per MIL-STD-2105B. Accordingly, this concept was formulated and published as a generic guideline for missile systems in general (reference 1) but especially for those systems that do not have conventional high explosive warheads and/or large detonable Class 1.1 rocket motors. This approach was tailored to the Army's PAC-3 missile and this program undertook to follow the generic approach after completing the needed threat hazard assessment (THA) in reference 2. Sub-scale or "material characterization" test phase for the PAC-3 Program was completed but will not be discussed in detail in this paper. Results were presented at the NATO Insensitive Munitions Information Center (NIMIC) Workshop (see reference 3).

With the prior approvals from the tri-service hazard classifiers and the Army Insensitive Munitions Board (AIMB) of the integrated IM/FHC plan, the sub-scale testing was completed and based on those results and the THA, the PAC-3 full-scale IM/FHC test plan was completed and approved. Schedules, funding, and test planning were developed for the required full-scale IM/FHC tests. These full-scale tests were conducted at Eglin Air Force Base, FL during 1997-1998. The number of assets for the PAC-3 IM/FHC test program using this approach was reduced from 37 assets to the equivalent of 4 All-Up-Rounds (AURs) plus two Lethality Enhancers. This was a tremendous cost savings to the PAC-3 program. With the drastic reduction of the number of tests to be conducted and the importance of the technical results of the sub-scale testing already completed it became obvious that accumulating, organizing and presenting the results must be done with great care and clarity.

PAC-3 Full-Scale Test Instrumentation

With the reduction in the number of assets for IM/FHC testing and the high cost of each asset, it became apparent that there had to be adequate instrumentation of each explosive test to assess the results from an IM and hazard classification perspective. Some unique and challenging devices were used for the PAC-3 tests.

Each test was equipped with VHS video, high speed cine, still photographs, blast gage data, thermocouples, weather conditions, fragment maps

(fragments were weighed and location annotated). In addition to the "standard" instrumentation and data collection techniques, the following "unique" instrumentation was instituted for the PAC-3 tests.

In all tests involving the solid rocket motor (SRM), there was a pressure transducer located in the head-end of the motor. This enabled us to estimate the motor thrust based on the pressure measurement. Since the SRM was restrained in all tests, this was particularly necessary in the assessment of a "propulsive burn."

In the fast cook-off/external fire stack test there were additional instruments to provide data on events that were not apparent because of the smoke, but were necessary to determine the extent of the reaction. A piece of data that was considered useful was when did "burn through" of the graphite-epoxy canister occur. To determine this, thermocouples were located between the missile and the canister tube. Each section of the missile was wrapped with break wires in order to determine which section reacted first.

Heat flux gages (to measure radiant heat flux) had not been used extensively in the Army. In fact, it was difficult finding a test using heat flux gages to use as an example as to type of gage and distance from the fire. The recommended distance in TB 700-2 is 50 feet from the fire (based on 100 kg weight). The distance had to be scaled for the explosive weight in the PAC-3 fire test and then we needed to determine if the distance was from the item or the edge of the fuel pan. The fuel pan measured 25 feet x 35 feet x 12 inches deep and held approximately 4500 gallons of JP-8 fuel. It was determined to locate the gages 75 feet from the edge of the pan. Use of heat flux gages was a condition of approval from the Department of Defense Explosive Safety Board (DDESB).

Fragment collection in the sympathetic detonation test and the fire test has routinely been accomplished in the U.S. by fragment field searching. The PAC-3 Program used this method and additionally used the 2m x 3m aluminum screens (a NATO requirement) to further assess the fragment hazard.

Another challenge to the PAC-3 IM/FHC was the restraint of the SRM or more basically should the motor be restrained at all. There was a tremendous amount of discussion on this topic by the international IM community. It was determined, for the PAC-3 Program, it would be best to restrain the motor (in all tests) and use the motor's internal pressure measurement to assess a "propulsive burn." The method of restraint was very challenging in that it had to be able to hold a fully thrusting rocket motor and not interfere/disrupt the fragment throw pattern, required by the hazard classification community. Typical IM restraint systems, using barriers, walls, or cages, would all interfere with the fragment dispersion pattern. The graphite/epoxy case and the sparse use of metal further limited options for the motor restraint system. The resulting restraint device, approved by the Army hazard classifier and the AIMB, restrained a fully thrusting rocket motor in impact and thermal tests, provided minimum interruption of fragment dispersion pattern and avoided any artificial heat path into the motor.

PAC-3 IM/FHC Full-Scale Test Results

Table I summarizes the tests conducted and the tentative scoring expected for each, remembering that the decision on Pass or Fail remains to be determined and reviewed by the Army IM Board and ultimately by review at the DOD level.

Summary Table

Test	*Article Description*	*IM Results*
Sympathetic Detonation (SD) Test	2 LE Sections each in Canisters, Side-by-Side. Initiate one.	No SD **PASS**
Bullet Impact (BI) - Lethality Enhancer (LE)	1 LE Section in Canister 3-7.62 mm. Bullets, 2,300 ft/sec.	No Reaction More Severe than Burning (NRMSB) **PASS**
Bullet Impact (BI) - Attitude Control Section (ACS)	1 ACS in Canister 3-7.62 mm. Bullets, 2,300 ft/sec.	NRMSB **PASS**
Fragment Impact (FI) - Lethality Enhancer (LE)	1 LE Section in Canister 6,576 ft./sec. Army Fragment	Detonation **FAIL**
Fragment Impact (FI) - Attitude Control Section (ACS)	1 ACS in Canister 6,476 ft./sec. Army Fragment	NRMSB **PASS**
Bullet Impact (BI) - Solid Rocket Motor (SRM)	1 SRM in Canister 3-7.62 mm. Bullets, 2,300 ft/sec.	Deflagration* Propulsiveness Fragments Thermal Flux
Fragment Impact (FI) - Solid Rocket Motor	1 SRM in Canister 6,200 ft/sec	Deflagration* Propulsiveness Fragments

(SRM)	Army Fragment	Thermal Flux
Fast Cook-Off (FCO)/External Fire Stack (EFS) Test	4-Pack (2 Live Msl;2-Inert Msl) 55 min. fuel fire; avg temp-1,600 degrees F.	Deflagration* Propulsiveness Fragments Thermal Flux

*TBD = To Be Determined

The tests conducted followed the guidelines established in the PAC-3 Integrated IM/FHC Test Plan as discussed in detail in Reference 4. The tests were conducted by the 46th Test Wing at Eglin Air Force Base, Florida during the period from 5 November through 4 March, 1998. The final test report is being written and delivery is expected by Eglin in July 1998. The test assets were assembled and delivered to Eglin by the PAC-3 prime contractor, Lockheed Martin Vought Systems, Dallas, Texas. For the BI, FI and SD tests the major missile components,(i.e. the LE, ACS and SRM) were each housed in a section of their graphite canister with suitable confinement to represent one round of the four pack. For the FCO/EFS test, a full 4-pack canister was used.

Sympathetic Detonation Test of the Lethality Enhancer (LE).

The LE is located in the mid-section of the missile and is activated for command destruct. The LE houses less than one pound of a low density, low order explosive material. This test is performed to determine whether the accidental detonation of one LE by design or other stimulus, could cause a sympathetic reaction of one, or more adjacent LEs. The test was initiated by firing one LE in the design mode and observing the reaction of the adjacent LE. The acceptor LE was knocked approximately 50 feet from the test stand but did not react in any way. The side of the graphite canister of the acceptor that was directly adjacent to the donor had a hole in it approximately the size and shape of the donor LE. The acceptor LE (and missile midsection) was visible through the hole in the canister. The outer surface of the midsection (housing the LE) was marred and nicked but it was obviously still intact. The witness plate, air blast gages and photo/video records all confirmed that there was no sympathetic reaction of the acceptor LE assembly.

Bullet Impact Tests

For the bullet impact tests three components were tested - the LE, the ACS and the SRM. In each case, the test article inside it's canister section was positioned on the test stand which served also as a witness plate should any detonation occur. Prior to each test, an explosive calibration charge of Comp C-4 was detonated for reference in reducing blast gage data. The BI test consisted of firing three rounds of 7.62x51 mm NATO, 150 grains Full Metal Jacket (FMJ) rounds from an M-60 machine-gun. The rounds were down-loaded to 2,300 ft/sec muzzle velocity as recommended in the THA. Each test was instrumented with blast gages in 4 arrays of 5 each, real-time video and high-speed cameras. (See Figure 1 for a typical test arena set-up.)

BI Test on the LE

The LE test article configuration was similar to that tested in the SD test. Upon firing the machine-gun, a puff of smoke was expelled from both ends of the canister and a mild "pop" was heard. A greenish smoke continued to evolve from one end (mostly) of the canister for approximately 3 minutes. No further reaction was noted. Post-test inspection revealed the bullets had not exited the far side of the canister. The plywood covers were not dislodged. There was no debris thrown from the test assembly and no noticeable blast recorded on the blast gages.

BI Test of the ACS

The BI/ACS test set-up was the same as for the BI/LE test. Three rounds of 7.62 mm bullets were fired to impact the ACS along a path to assure hitting the live thermal battery inside the ACS. A blast calibration shot preceded the test as discussed above. Upon firing the three rounds, a "pop" was heard and the forward and aft plywood covers were expelled, each landing within 15 feet of the test stand. Smoke was observed from both open ends of the canister for about 12 minutes, changing slightly as the wind changed. Post-test inspection revealed the three bullets had not exited the far side of the canister. The canister was still completely intact on the test stand. There was no debris thrown from the test item. It appeared that several Attitude Control Motors (ACMs) had ignited and burned in place. Several more ACMs were dislodged and lying at the bottom of the canister. Their condition could not be determined, due to EOD precautions about further handling of the item. There was no noticeable blast recorded.

BI Test of the SRM

Prior to the BI/SRM test two blast calibration shots were fired to cover the possible range of blast from the solid rocket motor. The SRM in its canister was restrained at both ends to prevent any significant movement upon ignition. The head-end of the motor was fitted with a metal collar through which four long rods were attached and

extended the front cover plate. These rods were then connected to a thrust measuring assembly attached to a thrust block. This provided a measure of thrust generated during the test. The aft-end was secured by cables to anchor bolts driven 8 ft into the ground. The test set-up was the same in general as for the BI/LE and BI/ACS tests. The PAC-3 SRM is a case bonded composite propellant rocket motor, and is 10 inches in diameter. It contains over 300 pounds of a HTPB/AP/Al propellant. The rocket motor had a head-end pressure transducer installed to aid in estimating propulsiveness of the test item. Upon gun firing, the motor ignited and flame from the rear side was immediately seen. Flame from the front (bullet entrance) side appeared a little later. The video records show some nozzle exhaust for a few seconds with noticeable chuffing. The motor burned for about 60 seconds. There was no noticeable blast recorded. When the remains could be viewed the next day, it was seen that the canister/motor had burned completely through. The forward section was still in place on the test stand, held by the four rods attached to the thrust stand. The aft-section was on the ground about 15 ft from the test stand and still attached to the cables. The cruciform from the missile's restraint system (necessary to secure it in the launch tube during shipping and handling) was expelled rearward and found beyond 50 ft. Several pieces of unburned propellant were also found some distance away. Note also several propellant firebrands were found. A complete analysis of the motor pressure and thrust data is now underway.

Fragment Impact Tests

Fragment impact tests were conducted on the LE, ACS and SRM. Eglin used a light-gas gun to propel a single standard Army Fragment at a nominal velocity of 6,000 ft/sec. The test samples were identical to the component samples in their canister sections as discussed in the BI tests above. The test set-up was typical of that run in the bullet impact tests. Blast calibration charges were fired as before.

FI Test of the Lethality Enhancer

On the first test of the LE, the fragment was slightly off the desired impact point and penetrated through the sample without hitting reactive material and resulting in no response of the test article. The light gas gun was re-aimed and fired again. The second shot hit as desired. There was an immediate loud report and the sample was blown apart. The reaction was obviously a detonation. No part of the test article remained on the table. Debris consisted of many small pieces of canister material and other hardware along with some larger sections thrown beyond 50 ft. Blast gages registered measurable amounts of pressure but analysis showed that the " TNT" equivalence was still less than the amount of explosive in the LE and related ordnance. The reported velocity of the fragment was 6,500 ft/sec.

FI Test of the ACS

Upon impact of the fragment, there was a mild "pop". The plywood covers were blown off, one landing at 85 ft and the other at 90 ft from the test stand. There was no penetration of the far side of the canister. The whole test article was pushed back about 2.0 inches at the impact point, remaining on the test stand. Smoke was observed coming from the ends of the canister. At about 40 seconds, a flash was seen indicating one or more ACMs ignited. A second flash and 'pop ' was observed at 78 seconds. The test article continued to emit smoke for a total of 5 minutes in decreasing amounts. No further reactions were observed. There were a large number of burned and perhaps some unburned ACMs at the bottom of the canister. The only debris thrown from the test area were the two plywood covers. There was no measurable air-blast.

FI Test of the SRM

Upon impact of the single fragment, the motor immediately ignited and a sizable plume was seen burning from the impact point and a very brief plume from the nozzle as well. No burning was seen from the rear (exit) side of the sample indicating that the fragment did not travel completely through the motor. The motor burned for about 80-90 seconds with decreasing signature. Post-test inspection showed that the motor tried to move off of the test stand but was restrained by the head-end thrust assembly and the rear-end cables. There was noticeable bending and deformation of the sample indicating lateral thrust. There was no noticeable air-blast. The aft cruciform was ejected and recovered 172 ft away. The thrust plate assembly was pulled loose on one side indicating significant lateral thrust. Preliminary look at the thrust data confirms significant thrust for a short period and these data are now being analyzed. Along with the motor head-end pressure gage record, they should allow an estimate of motor thrust versus time. It is clear that the motor would have moved some distance if not restrained.

Fast Cook-Off/External Fire Stack Test of the 4-Pack

The eighth and final test was a test of a PAC-3 4-Pack canister loaded with two live rounds and two inert mass simulators all inside a tactical full size canister, The missile assemblies contain all of the live ordnance associated with the LE, ACS and SRM with mass simulators for inert parts. The two

inert rounds were simple cylindrical rods simulating the All-Up-Round (AUR) mass. The two live missiles were fitted with head and aft restraints as discussed in the BI/SRM and FI/SRM sections and as shown in Figure 9. Each live round was instrumented to provide additional information about the sequence of events that occurred during the test. (See instrumentation section above.) The instrumentation leads were brought out the top of the 4-pack assembly and thermally protected. To establish the temperature of the fuel fire around the sample, four thermocouples were positioned in a plane through the middle of the overall canister sample and about 12 inches from the exterior of each side and end. Measurements of the thermal flux of the test were obtained by use of thermal flux gages on the four quadrants at a distance of 75 ft from each pan edge. To aid in the analysis of video and photo data, black and white marker poles were positioned along four axes at intervals of 25 ft. To satisfy the requirements of TB 700-2 for final hazard classification, aluminum witness panels were installed at 4 meters from the edge of the pan in three directions. For this test, a thermite grenade was positioned above the fuel surface on a concrete block at one corner of the pan and initiated. The flame spread slowly across the pan and engulfed the sample after about two minutes. Inspection of the site post-test was allowed the next day after the test. All of the black and white reference poles were still in place. The three aluminum witness panels were in place and there was only one perforation, towards the top of the north panel. Most of the remains of the test article had stayed in place and were severely burned. The instrumentation cables from the head-end were unbroken. When the head-end pressure data is obtained, an assessment of motor pressure and thrust will be attempted. Visual review of the sample and restraint cables post-test did not reveal any obvious movements from thrusting. There were several obvious propellant fire-brand impacts of some size as seen on the video and as witnessed by the white residue found. One of the cruciforms was found approximately 100 ft away, and one was found in the fuel pan. There were numerous very small fragments of graphite canister material scattered around of such small size as to be non-hazardous. A complete tabulation of debris will be provided in the Eglin Final Test Report. Post-test inspection shows the remains of expended ACM's still trapped in the debris. Due to the jumble of the remains of the two live rounds mixed with the canister debris and the fact that EOD would not allow digging or moving of these remains because of the possibility of some live material remaining, some speculation is involved in the following comments. It appeared that the lower rocket motor ignited first at 32 minutes and 31 seconds after the fire was fully developed, and ruptured soon thereafter causing dispersal of firebrands and flame to the right side (looking from the aft end). The second motor was probably ignited at this time. Approximately 3 minutes, 3 seconds after the first motor ruptured, the second motor also ruptured with additional flame and firebrands. Together, the motors burned for an additional 1-2 minutes. It is difficult to separate the visible effects of the burning motor(s) from the continuous burn of the fuel fire with the copious amounts of black smoke generated. Here again, the thermocouple data will hopefully allow one to say more definitively what the sequence of events was. Almost all of the canister was consumed by the time the fire died out. During the fire, after the rocket motors ignited, there could be seen the flight of individual ACM's that had gotten loose, ignited and were expelled some distance from the test article. The videos show numerous such events for about 5 minutes and fewer for another 8 minutes. In all, 38 ACM's or pieces were found scattered beyond the test sample. Post-test inspection shows the remains of expended ACM's still trapped in the debris. The exterior of both LE sections appeared to be intact to indicate that neither unit detonated. Undoubtedly they did burn but the time cannot yet be determined. The absence of any violent reaction is indicated by the fact that the Aluminum witness panels and the black and white reference poles all remained standing and no measurable blast was recorded.

Conclusions

The required full-scale IM/FHC tests have been completed for the PAC-3 missile system according to the test plans approved in advance by the Army IM Board and the Army and DDESB hazard classification authorities. The reactions were mild although some may not necessarily be considered as "pass" according to current interpretations of Mil Std 2105-B. This program has been the most ambitious ever for the Army in showing the wisdom and cost savings possible by combining IM and FHC requirements in a logical way, making full use of the Threat Hazard Assessment and maximizing the use of sub-scale tests.

PAC-3 IM/FHC Test Program Database

A key denominator in all of the testing described above is the assessment of the violence of the munition reaction when it is subjected to the specified stimulus. Words alone hardly convey to the reader the difference between "burning only" and "deflagration" or "explosion." While conventional

engineering data such as velocity of reaction, presence or absence of perforation of a witness plate and airblast measurements all provide the non-expert IM reader some basis for understanding, there is still a need for a better "picture" of what really happened. Of course, this "picture" is provided through still photographs, real time video and high speed cine records of the test. Heretofore these exist as separate pieces of the data package and exist in cumbersome format. Early efforts to integrate the video portion of IM/FHC testing into an overall database and provide access to a specific test record in a timely manner were conducted under a Thiokol Corporation IR&D task at the Huntsville Division. In this effort (reference 5) a large number of IM test video records were edited down into one master VHS videotape. This was then transcribed onto a laser videodisc. This format provides about 30 minutes of high quality visual records of many discrete tests. Futhermore, any individual record can be found and played quickly by controlling the laser videodisc player by a simple computer program. Thus, one may in a few seconds go directly to the selected test video as each sequence has an address that can be quickly found. Additionally, the individual video frames can be viewed singly as desired or played at any specified rate to provide stop action or slow speed playing.

Since the laser videodisc activity was accomplished, the state-of-the-art for PC's has advanced to the point that the accumulation of a conventional alpha-numeric test database along with still photographs and video records may now be accomplished within the PC itself. This allows for a true integration of all of these formats into a single record set that is then available for database searching, retrieving, analysis and ultimately available for direct transmission to other PC's or output onto a permanent CD. With the cooperation of the U.S. Army Aviation and Missile Command's Propulsion Directorate, the PAC-3 IM/FHC documentation was collected and established as a test/video record to demonstrate the utility and application of this approach.

Description of the System

The database is designed to utilize currently available PC computer technology and the Gateway 2000 PC was selected as the main component. Most current PC's can handle the needed alpha-numeric text information used in this database. The incorporation of the video function into the PC requires some additional hardware and software. The amount of storage necessary to hold one single high quality color frame is about 1.5 megabyte (MB). Since conventional video contains 30 frames per second, one minute of real time video would require 2,700MB. This would quickly overwhelm the typical hard drive and makes video incorporation unrealistic without the recent advances in compression/decompression. Another limiting factor is the resolution needed for the image itself. In the system being demonstrated the video record recorded into the CD has a resolution of 320 x 240 pixels. When this image is displayed on a computer screen, which has 640 x 480 pixels, the CD image occupies one quarter of the screen without loss of clarity. But when this image is expanded to full screen (640 x 480) there is a noticeable loss of sharpness but an acceptable image is still maintained. Other limitations are the transfer rate of information from the CD to the computer may also result in some loss of image quality since the 30 frames/second original video frame rate becomes effectively 15 frames/second as processed by the computer.

All of these limitations are being carefully considered and this database development is being designed for the advances expected in the next 1-2 years. Any loss in image quality now will be alleviated as the storage size and transfer speed of the next generation CD's increases. A typical IM test record can be edited down to 1-2 minutes of critical time to show the initiation of the test sample and its reactions. Some cook-off tests require much longer real times but the time spent waiting for the initiation can be abbreviated as long as the actual reaction is caught. For bullet impact, fragment impact and similar tests where the reaction initiation is controlled and predictable, high speed framing camera records are usually taken at framing rates of a few thousand up to 40,000 frames /second. Once obtained, these records may be converted to video tape and included as input into this database. After conversion, these records are usually only a few seconds long (a hundred frames). Each test also has a dozen or two color, still photos of the test article before and after the test and these become a part of the visual record input to the database. These inputs flow into the system and once they are input they are handled using the software and hardware as indicated in Figure 3.

PAC-3 Inputs

The overall structure of the database is shown on the main menu. From this menu the viewer may click on any of the options indicated. In order to see the PAC-3 effort, one might click on the Detailed Test Plan and would then see the table of contents of the test plan. The complete contents of the test plan may be viewed by scrolling through the document. Alternately, the viewer might elect to go directly to one of the appendices and see the test results or the

THA. When the PAC-3 efforts were begun, the format for the database had not been established. The PAC-3 propulsion contractor, Atlantic Research Corporation, conducted tests and submitted reports accordingly in their own preferred format.

The format selected for this database is Microsoft Word for PC in consonance with the government wide selection of this format as a standard for government reports and correspondence. Since not all of the previous tasks under the PAC-3 Program were prepared in Word it is has taken longer to input these into the database. Future test and analysis activities will be required to submit their data and reports in Word 6.0 (or higher) to facilitate inclusion in this database. Use of Adobe has greatly enhanced this effort. Regardless of the word processing package, the file is changed to a "pdf" file using Adobe editing. The database is now able to handle documents created in Word, WordPerfect, or Macintosh.

Once the text data is entered into the computer and a structure is established, the still photos of before and after test set-ups are entered. This system uses a color scanner to directly scan the photos (those not received digitally) and store the image. The images may then be loaded anywhere in the database. Inputting the video records can be accomplished from a VHS tape, laser disc record, or directly from a digitized video camera record if this is available. The computer is equipped with a video capture card that allows video editing in conjunction with the Adobe Premier software. Each frame (30 frames per second) of the video record is discretely stored in memory and may be viewed, transposed or edited. For PAC-3, the video frames of the test before and long after the actual event are deleted so that the record contains the actual reactive portion of time.

After being input, edited and integrated into the database, the results may be viewed on the screen of the PC or these records may be transmitted electronically to any other computer station just as currently done with other e-mail. A better option is to output the files onto a CD to establish a permanent record that can be physically carried or sent to a desired location. Outputting to a CD requires the CD writing equipment and the current effort uses a Smart and Friendly EX-CE Pro.

Current limitations on CD storage capacity allow a relatively small amount of video storage but the next generation CD is expected to increase the storage capacity by a factor of 10 or more.

All of the above capabilities are being demonstrated in the system developed under this task and can be handled by a current PC. For this conference, the system is being operated from a PC laptop by playing of a CD record generated with information available to date. Viewing may be accomplished by seeing the laptop screen or by the use of an ancillary projector to project an image onto a larger screen. This provides a convenient capability to make presentations without carrying a large number of conventional viewgraphs. Also the presenter has access to the complete database file and can find any other information needed to respond to unexpected questions.

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5. Thomas, William B. Unpublished. Correspondence regarding the development of a Laser Video Disc Database for IM Testing. Thiokol Corporation IR&D Program for 1990-1994.

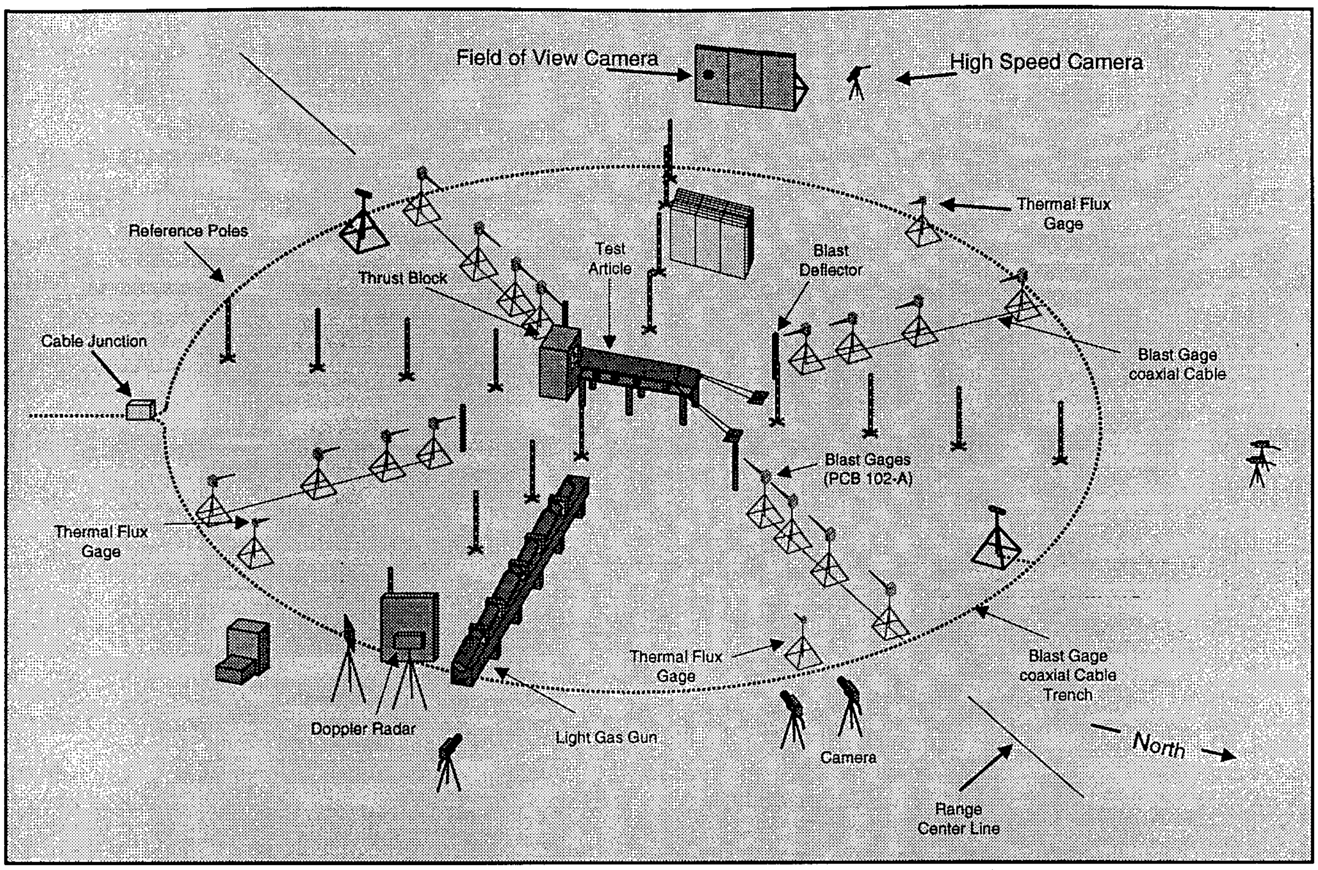

Figure 1: Typical Test Setup

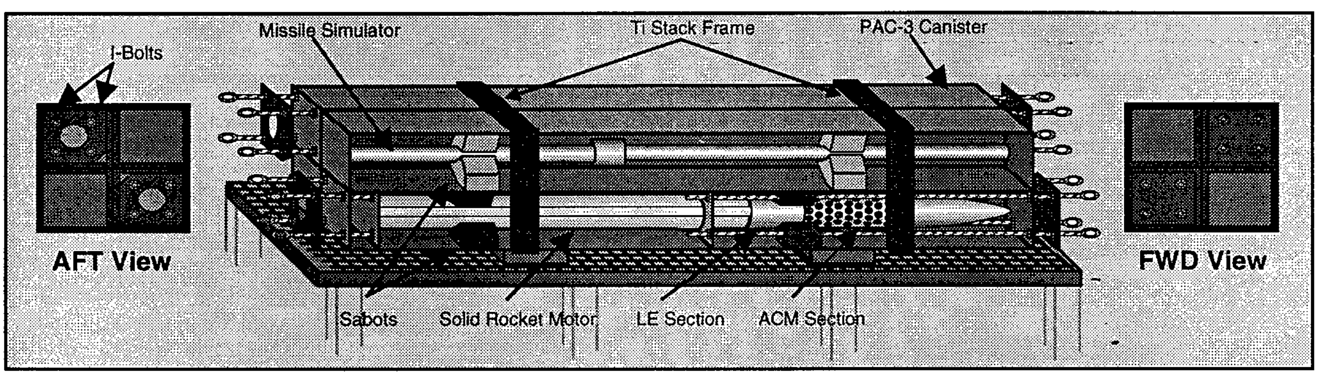

Figure 2A: FCO / EFS Test Article

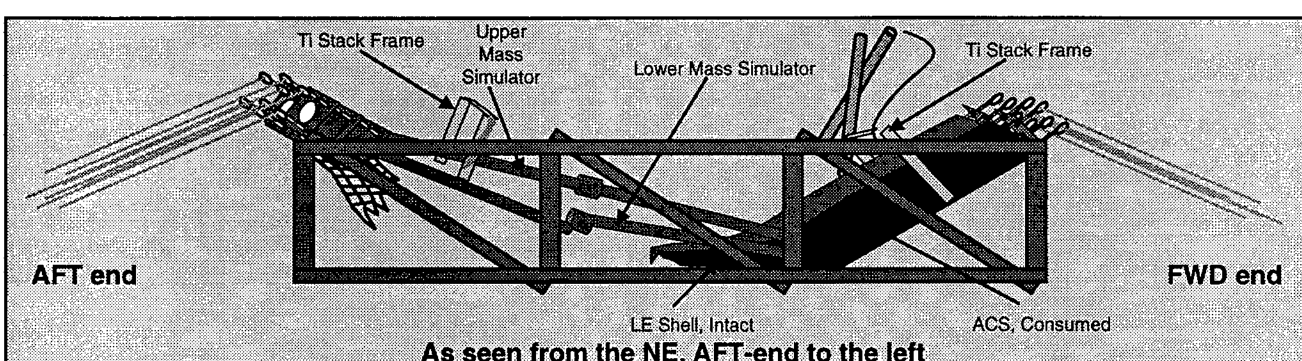

Figure 2B: FCO / EFS Test Article

M-980129-01U.ppt

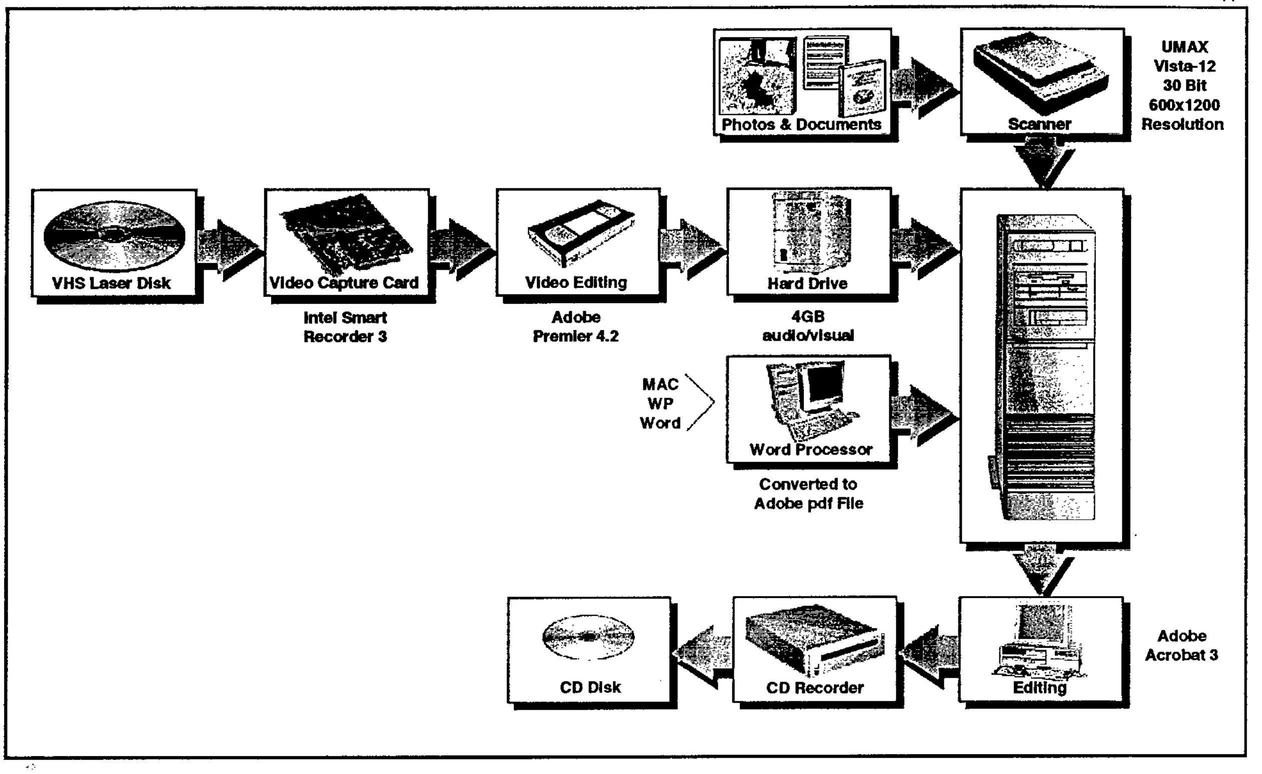

Figure 3. IM/FHC Test Program Database